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# Trends in influenza vaccination behaviours – results from the CoPanFlu cohort, France, 2006 to 2011

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**Controversies over the effectiveness and safety of the pandemic influenza A(H1N1)pdm09 vaccine in 2009/10 may have altered the influenza vaccination coverage in France after the pandemic season. The purpose of this study was to determine whether the pandemic affected seasonal influenza vaccination behaviours in the general population by analysing vaccination behaviours from 2006/07 to 2011/12 among the 1,451 subjects of the Cohort for Pandemic Influenza (CoPanFlu) France. We found that vaccination behaviours in 2010/11 and 2011/12 significantly differed from behaviours before the pandemic, with the notable exception of the targeted risk groups for seasonal influenza-related complications. Among the population with no risk factors, the post-pandemic influenza vaccine coverage decreased, with people aged 15 to 24 years and 45 to 64 years being most likely to abandon vaccination. Therefore, this study documents a moderate negative effect of the 2009/10 pandemic episode on vaccination behaviours in the French metropolitan population that was apparent also in the following two seasons. Moreover, it does not exclude that the general trend of reduced vaccination has also affected certain targeted groups at high risk for complications.**

## Introduction

The public health response to the 2009 pandemic of influenza A(H1N1)pdm09, which first appeared in May 2009 in France, as in many European countries, largely focused on vaccination [1]. From June 2009, the question of vaccine availability was replaced in France by a growing controversy on the relevance and safety of pandemic vaccination and possible conflicts of interest between pharmaceutical companies and experts [2,3]. Two vaccines became available during the 2009/10 pandemic season in France: first a vaccine against seasonal influenza strains (seasonal vaccine), and later a vaccine against the pandemic strain (pandemic

vaccine). French health authorities launched campaigns to promote both seasonal and pandemic vaccinations, aimed at protecting the entire population [4], but especially targeting usual and new risk groups [5]. In January 2010, the number of influenza infections was under the epidemic threshold in metropolitan France and the vaccination campaigns subsequently stopped.

Only around 8% of the French population got vaccinated against pandemic influenza [2,3]. A considerable body of research has been devoted to the failure of the 2009/10 pandemic vaccination campaign [6] and to the determinants of intentions and decisions to get this vaccine [7-9]. Yet few studies have examined the potential effect of controversies about vaccines on people's general vaccination behaviours and the rare studies addressing change in influenza vaccination behaviours in Europe after the pandemic have mostly focused on high-risk groups [10-12]. The purpose of this article is to further examine the evolution of influenza vaccination behaviours in relation to the pandemic: (i) whether and how influenza vaccination behaviours after the pandemic changed, and (ii) if some population groups, especially target groups, were particularly affected in their behaviours.

## Methods

For this study, longitudinal data from the Cohort for Pandemic Influenza (CoPanFlu) France interdisciplinary consortium were used. The cohort consists of 1,451 individuals from 575 households representative of the French population, and was set up in December 2009 to study the risk of influenza A(H1N1)pdm09 infection and its determinants. Study design, e.g. sampling methods, eligibility criteria and data collection have been described in detail elsewhere [13]. The research ethics committee 'Comité de Protection des Personnes Ile-de-France 1' approved the protocol of the study, and

**TABLE 1**

Sociodemographic characteristics of the CoPanFlu cohort subjects, France, 2009–2012 (n=1,451)

	n	% of the sample	95% CI
<b>Sex</b>			
Male	685	47.2	44.6–49.8
Female	766	52.8	50.2–55.4
<b>Age group at the inclusion</b>			
Under 15 years	276	19.0	17.0–21.0
15–24 years	161	11.1	9.5–12.7
25–34 years	142	9.8	8.3–11.3
35–44 years	200	13.8	12.0–15.6
45–54 years	219	15.1	13.3–16.9
55–64 years	237	16.3	14.4–18.2
65 and older	216	14.9	13.1–16.7
<b>Target groups</b>			
65 years and older	216	14.9	13.1–16.7
Under 65 years with a target condition	184	12.7	11.0–14.4
No risk factors	1,051	72.4	70.1–74.7
<b>Educational level</b>			
Primary education and lower	104	7.2	5.9–8.5
Secondary education	327	22.5	20.4–24.6
Upper secondary education	243	16.7	14.8–18.6
Higher education	419	28.9	26.6–31.2
Information not available	358	24.7	22.5–26.9
<b>Monthly household income</b>			
Under EUR 1,500	215	14.8	13.0–16.6
EUR 1,500–3,000	522	36.0	33.5–38.5
EUR 3,000–4,500	421	29.0	26.7–31.3
EUR 4,500 and higher	200	13.8	12.0–15.6
Information not available	93	6.4	5.1–7.7
<b>Total</b>	<b>1,451</b>	<b>100.0</b>	

CI: confidence interval.

informed consent was collected for each subject at the inclusion phase. In 2010/11, 37 subjects had left the study (2.5% of the sample), and a further 94 individuals (131 in total, 9.0% of the sample) had left the study when the research protocol has been extended to the 2011/12 season. Their sociodemographic characteristics were not significantly different from the rest of the cohort.

## Measures

This study presents data on vaccination behaviours from the influenza seasons 2006/07 to 2011/12, collected among all 1,451 individuals of the cohort. During the inclusion visit that took place between December

2009 and July 2010, the participants declared whether they had received the influenza vaccination during the three seasons before the pandemic (2006/07, 2007/08 and 2008/09) and the seasonal, pandemic or both influenza vaccinations in 2009/10. During follow-up visits and in questionnaires, cohort subjects were asked to report their vaccination status in 2010/11 and in 2011/12. At inclusion, subjects also provided their sociodemographic characteristics, which are presented in Table 1.

Data on education were divided into four levels using the 1997 International Standard Classification of Education developed by UNESCO and adapted for France by the Eurydice network [14]. Information on educational level was mostly unavailable for children under the age of 15 years.

Risk groups were defined using criteria for seasonal influenza vaccination before the H1N1 influenza pandemic, as vaccination is recommended by the French health insurance system and free of charge for individuals with a risk factor for complications in case of an infection (65 years or older and some medical conditions) [12,15]. Two target (at-risk) groups were differentiated according to their age and clinical data collected during the inclusion visit: subjects aged 65 years and older at the inclusion visit (who may or may not have a condition placing them in a risk group) and those aged younger than 65 years with a risk condition.

## Statistical analysis

Differences in independent groups were tested using a two-tailed Pearson's chi-square test. The McNemar test and the Cochran test, respectively, were applied to test the significance of changes in (dependent) vaccination behaviours of the cohort's subjects between two and more than two seasons [16]. A series of logistic regression analyses was performed to examine the association between vaccination behaviours and a range of sociodemographic factors. All statistical analysis was executed using IBM SPSS statistics version 20.

## Results

### Behavioural change during the pandemic in the cohort

Variations in vaccination behaviours before, during and after the pandemic were first investigated ( $p < 0.0001$ , Tables 2 and 3). Before the pandemic, vaccination behaviours were not significantly different over time, and influenza vaccination coverage (IVC) remained stable over the period from 2006/07 (20.6%, 95% confidence interval (CI): 18.5–22.1), 2007/08 (20.6%, 95% CI: 18.5–22.1) to 2008/09 (21.3%, 95% CI: 19.2–23.1, Cochran test not significant).

As shown in the Figure, vaccination behaviours changed significantly during and after the pandemic season. In 2009/10, an increase in total IVC (for all influenza vaccines combined) can be observed compared to the

**TABLE 2**

Influenza vaccination coverage in the CoPanFlu cohort from 2006/07 to 2011/12, all data, France (n=1,451)

Influenza season	Vaccination status (pandemic, seasonal or both vaccines)												Total
	Vaccinated			Not vaccinated			Don't remember			Missing data			
	n	%	95% CI	n	%	95% CI	n	%	95% CI	n	%	95% CI	n
2006/07	287	20.6	18.5–22.7	1,090	78.1	75.9–80.3	13	0.9	0.4–1.4	6	0.4	0.1–0.8	1,396
2007/08	292	20.6	18.5–22.7	1,107	78.2	76.0–80.4	9	0.6	0.2–1.0	7	0.5	0.1–0.8	1,415
2008/09	304	21.3	19.2–23.4	1,114	77.9	75.8–80.0	6	0.4	0.1–0.7	6	0.4	0.1–0.7	1,430
2009/10 <sup>a</sup>	240	16.5	14.6–18.5	1,025	70.6	68.3–73.0	1	0.1	0.0–0.2	0	0.0	0.0–0.0	1,451
2009/10 <sup>b</sup>	100	6.9	5.6–8.2										
2009/10 <sup>c</sup>	85	5.9	4.7–7.1										
2010/11	253	17.9	15.9–19.9	1,158	81.9	79.9–83.9	0	0.0	0.0–0.0	3	0.2	0.0–0.5	1,414
2011/12	253	19.2	17.1–21.3	1,059	80.2	78.1–82.4	7	0.5	0.1–0.9	1	0.1	0.0–0.2	1,320

CI: confidence interval.

<sup>a</sup> Seasonal vaccination only.<sup>b</sup> Pandemic vaccination only.<sup>c</sup> Both vaccinations.**TABLE 3**

Influenza vaccination coverage in the CoPanFlu cohort from 2006/07 to 2011/12, excluding missing data, France (n=1,451)

Influenza season	Vaccination status <sup>a</sup> (pandemic, seasonal or both vaccines)						Total
	Vaccinated			Not vaccinated			
	n	%	95% CI	n	%	95% CI	n
2006/07	287	20.8	18.7–22.9	1,090	79.2	77.1–81.3	1,377
2007/08	292	20.9	18.8–23.0	1,107	79.1	77.0–81.2	1,399
2008/09	304	21.4	19.3–23.5	1,114	78.6	76.5–80.7	1,418
2009/10 <sup>b</sup>	240	16.6	14.7–18.5	1,025	70.7	68.4–73.0	1,450
2009/10 <sup>c</sup>	100	6.9	5.6–8.2				
2009/10 <sup>d</sup>	85	5.9	4.7–7.1				
2010/11	253	17.9	15.9–19.9	1,158	82.1	80.1–84.1	1,411
2011/12	253	19.3	17.2–21.4	1,059	80.7	78.6–82.8	1,312

CI: confidence interval.

<sup>a</sup> The missing data are excluded.<sup>b</sup> Seasonal vaccination only.<sup>c</sup> Pandemic vaccination only.<sup>d</sup> Both vaccinations.

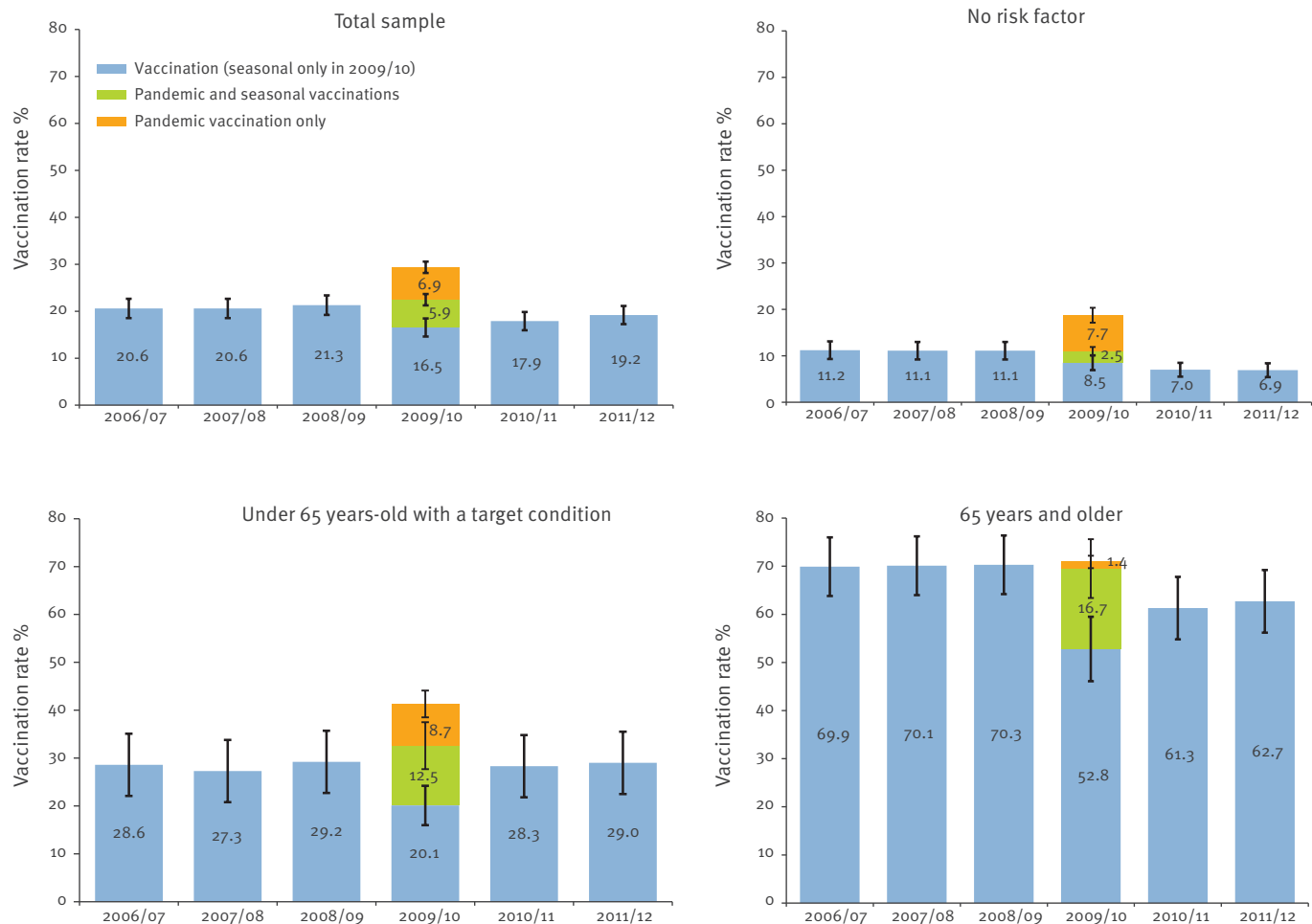
2008/09 season (29.4%, 95% CI: 27.1–31.7,  $p < 0.0001$ ), with an IVC for the pandemic vaccine (only or in combination with the seasonal vaccine) of 12.8% (95% CI: 11.1–14.5) and an IVC for the seasonal vaccine (only or in combination with the pandemic vaccine) of 22.5% (95% CI: 20.4–24.6). It should be mentioned that 5.9% of the sample received both vaccines (95% CI: 4.7–7.1, Table 3). However, the total seasonal IVC in 2009/10 was not significantly higher than in 2008/09.

Among subjects who had not left the study in 2011/12, the total IVC was significantly lower in 2010/11 than the

total seasonal IVC in 2009/10, with a decrease of 17.9% (95% CI: 15.9–19.9,  $p < 0.0001$ ). Among subjects who had not left the study in 2011/12, vaccination behaviours in 2011/12 were not significantly different from those observed in 2010/11. Using paired tests and considering subjects who were still in the study in 2010/11 and in 2011/12, respectively, vaccination behaviours in 2010/11 and in 2011/12 were significantly different from those observed in 2008/09, with lower IVCs after the pandemic ( $p < 0.0001$ ).

## FIGURE

Influenza vaccination coverage from 2006/07 to 2011/12 in the total CoPanFlu cohort and according to risk factors for seasonal influenza, France (n=1,451 until 2009/10, n=1,414 in 2010/11, n=1,320 in 2011/12)



### Behavioural change during the pandemic according to risk factors

Vaccination behaviours varied according to the presence of risk factors (Pearson's chi-square test,  $p < 0.0001$ , Figure), with people with no risk factor not surprisingly demonstrating the lowest IVCs across all seasons. Similarly to the general population, their vaccination behaviours were stable before the pandemic, an IVC increase was noted in 2009/10 and a decrease in 2010/11.

Among target groups, individuals aged 65 years and over had better coverage before, during and after the pandemic than those younger than 65 years with a target condition or those with no risk factor (Pearson's chi-square test,  $p < 0.0001$ ). In 2008/09, the season before the pandemic, IVCs ranged from 70.3% (95% CI: 64.2–76.4) for individuals aged 65 years and over to only 29.2% (95% CI: 22.7–35.7) for those under age 65 years with a target condition, and 11.1% (95% CI: 9.2–13.0) for individuals with no risk factor (Figure). Compared with 2008/09, only the subjects younger

than 65 years with a target condition increased their total seasonal IVC in 2009/10 (seasonal vaccine only or seasonal and pandemic) to 32.6% (95% CI: 30.2–35.0,  $p < 0.05$ ) (Figure).

During the pandemic, subjects with no risk factor (as defined for seasonal influenza) were significantly less likely to be vaccinated than the two target groups ( $p < 0.0001$ ), almost as likely to use the pandemic vaccine (7.7%, 95% CI: 6.4–9.1) as the seasonal vaccine (8.5%, 95% CI: 7.1–9.9) and rarely got immunised against both strains (2.5%, 95% CI: 1.7–3.3). Among target groups, subjects 65 years and older almost never got vaccinated against the pandemic strain only (1.4%, 95% CI: 0.8–2.0) and rather used it in addition to the seasonal vaccine (16.7%, 95% CI: 14.8–18.6). More than half of this latter target group got vaccinated only against the seasonal strain of influenza (52.8%, 95% CI: 50.2–55.4). Those under age 65 years at high risk for complications had the greatest total uptake of the pandemic vaccine compared with the two other groups (21.2%, 95% CI: 19.1–23.3,  $p < 0.001$ ) with 8.7% (95%

CI: 7.2–10.1) who got immunised only against the pandemic strain. Similar to those aged 65 years and over, persons under 65 years with a target condition relied more strongly on both vaccines that year (12.5%, 95% CI: 10.8–14.2) and on the seasonal vaccine only (20.1%, 95% CI: 18.0–22.2).

### Behavioural change after the pandemic

Vaccination behaviours in 2010/11 of subjects who were vaccinated in 2008/09 and had not left the study in 2010/11 (n=293) were then studied. Significant changes in vaccination behaviour were observed in the cohort after the pandemic season: 27.0% of the total sample vaccinated in 2008/09 did not get vaccinated again in 2010/11 (Table 4). The change in vaccination behaviours was significantly different according to risk factors (Pearson's chi-square test,  $p < 0.0001$ ): 45.4% of individuals with no risk factor, 21.6% of those under age 65 years with a target condition, and 14.2% of individuals aged 65 years and over abandoned influenza vaccination. In fact, considering individuals who had not left the study, vaccination behaviours in 2010/11 and in 2011/12 among people at high risk for complications were not statistically different from those adopted in the three seasons before the pandemic, whereas a significant IVC decrease was observed after the pandemic among subjects with no risk factor.

### Sociodemographic characteristics associated with vaccination behaviours

As a final measure, we explored sociodemographic factors associated with getting vaccinated in 2008/09 and with not getting vaccinated again in 2010/11 (for subjects with no risk factor and vaccinated in 2008/09). As the number of participants who were unvaccinated in the 2008/09 season and got vaccinated in the post-pandemic season was rather low, we decided not to perform a statistical analysis for this group.

In univariate analysis, getting vaccinated in 2008/09 was positively associated with every age group (compared with individuals under 15 years of age), with level of household income, as well as with primary education (unadjusted odds ratio (OR): 3.16, 95% CI: 1.52–6.57), but negatively associated with no information on education (unadjusted OR: 0.34, 95% CI: 0.18–0.69, compared with individuals with a higher education). As indicated in Tables 5 and 6, age and household income level remained significantly associated with the dependant variable in multivariate analysis.

Change in vaccination behaviours among subjects with no risk factor was positively associated with every age group (except an age equal to or older than 65 years, as they were excluded from the analysis) but strongest among individuals aged 15 to 24 years (adjusted OR: 10.75, 95% CI: 3.03–38.18), those aged 45 to 54 years (adjusted OR: 10.58, 95% CI: 2.91–38.53) and those aged 55 to 64 years (adjusted OR: 23.15, 95% CI: 6.39–83.85), compared with individuals under 15 years.

## Discussion

As in many industrialised countries during the 2009 influenza A(H1N1)pdm09 pandemic, public health authorities in France faced a climate of distrust toward the pandemic vaccine [6], which was extensively covered by the mass media [2,3]. It should also be noted that the pandemic vaccination effort was contested by a number of medical professionals and politicians [3,17]. One of the objectives of this article was to ascertain the impact of the controversies on subsequent influenza vaccination behaviours.

### An immediate impact on vaccination behaviour

This study shows an immediate impact of the pandemic episode on vaccination uptake rates that lasted for the period of the two following seasons observed in this study. The longitudinal setting of the CoPanFlu cohort enabled us to characterise behaviour changes among the same representative sample of the French population before, during and after the pandemic, which is often lacking in the literature [18,19]. A clear immediate effect of the pandemic season on influenza vaccination behaviours could be established (Tables 2 and 3). Despite the low pandemic IVC also recorded in other studies [2,3], cohort subjects were significantly more often vaccinated with the seasonal vaccine in 2009/10 compared with previous seasons, and sometimes got both vaccinations. Altogether, this resulted in a total IVC close to 30%. Vaccination behaviours in the total sample were found to be affected for two years after the pandemic in that IVCs in 2010/11 and 2011/12 were significantly lower than before the pandemic (Table 4). However, this trend can only be confirmed for the people with no risk factor for seasonal influenza, as statistical power was lacking to reveal such an effect among members of the target groups. Regarding the general impact of the pandemic season on vaccination behaviours, this study is to our knowledge the first to reveal such a significant drop in IVC after the pandemic in a longitudinal setting. Whether this trend will continue has yet to be confirmed, as it raises concerns for future vaccination campaigns and among specific population groups.

Pandemic vaccination was in fact recommended for new target groups that were not included in the French definition of target groups before the pandemic: pregnant women, parents of young children, and subjects with other specific pathologies or aged over 19 years with no risk factor [5]. Some of these groups were still included in the 2010/11 influenza vaccination recommendations [20]. As with the rest of the population, older age groups were more willing to get vaccinated during the pandemic, but less so in the following seasons. This is particularly illustrative of the controversial climate during the pandemic: individuals who got vaccinated against seasonal influenza before the pandemic season changed their behaviour. Controversies in 2009/10 and conflicts of interest between pharmaceutical companies and experts could have created doubts about the safety of influenza vaccines among

**TABLE 4**

Influenza vaccination status in 2010/11 of CoPanFlu cohort subjects who were vaccinated in 2008/09, France (n=293)

Vaccinated in 2008/09	Vaccination status in 2010/11 (pandemic, seasonal or both vaccines)							
	Remained vaccinated		Abandoned vaccination		Missing data		Total	
	n	%	n	%	n	%	n	%
Among the general population	213	72.7	79	27.0	1	0.3	293	100.0
Among those with no risk factor	59	54.6	49	45.4	0	0.0	108	100.0
Among those under 65 years (in 2010/11) with a target condition	40	78.4	11	21.6	0	0.0	51	100.0
Among those over 65 years and older (in 2010/11)	114	85.1	19	14.2	1	0.7	134	100.0

**TABLE 5**

Factors associated with getting vaccinated in 2008/09 and with getting vaccinated in 2008/09 (n=111) and abandoning vaccination in 2010/11 (n=49), univariate analysis, France

Factors	Dependant variable: vaccinated (with any influenza vaccine) in 2008/09 (n=111) (1)				Dependant variable: vaccinated (with any influenza vaccine) in 2008/09 and abandoned vaccination in 2010/11 (n=49) (2)			
	n	Unadjusted OR	95% CI	p value	n	Unadjusted OR	95% CI	p value
<b>Sex</b>								
Male	488	0.95	0.64–1.41	0.784	552	1.13	0.64–2.01	0.676
Female	562	Reference			470	Reference		
<b>Age group in 2008/09</b>					<b>Age group in 2010/11</b>			
Under 15 years	279	Reference			250	Reference		
15–24 years	124	6.17	2.49–15.31	<0.0001	141	7.46	1.56–35.63	0.012
25–34 years	141	3.29	1.25–8.68	0.016	125	10.78	2.33–50.01	0.002
35–44 years	175	2.86	1.10–7.41	0.030	169	4.56	0.91–22.89	0.065
45–54 years	166	6.89	2.91–16.32	<0.0001	171	6.89	1.47–32.29	0.014
55–64 years	165	14.57	6.39–33.24	<0.0001	166	11.42	2.56–50.95	0.001
<b>Educational level</b>								
Information not available	309	0.34	0.17–0.67	0.002	310	0.48	0.19–1.20	0.117
Primary education and lower	49	3.16	1.52–6.57	0.002	42	2.18	0.68–6.97	0.188
Secondary education	221	1.28	0.76–2.14	0.355	213	1.46	0.68–3.12	0.333
Upper secondary education	159	1.50	0.87–2.59	0.145	153	1.45	0.63–3.34	0.385
Higher education	312	Reference			304	Reference		
<b>Monthly household income</b>								
Information not available	50	0.41	0.14–1.23	0.112	53	0.71	0.15–3.46	0.672
Under EUR 1,500	140	0.45	0.22–0.93	0.031	134	0.85	0.29–2.51	0.768
EUR 1,500–3,000	385	0.47	0.27–0.81	0.007	379	0.80	0.33–1.91	0.613
EUR 3,000–4,500	318	0.69	0.40–1.17	0.167	303	1.08	0.45–2.56	0.866
EUR 4,500 and higher	157	Reference			153	Reference		
<b>Total of the sample</b>	<b>1,050</b>				<b>1,022</b>			

**TABLE 6**

Factors associated with getting vaccinated in 2008/09 and with getting vaccinated in 2008/09 (n=111) and abandoning vaccination in 2010/11 (n=49), multivariate analysis, France

Factors	Dependant variable: vaccinated (with any influenza vaccine) in 2008/09 (n=111) (1)				Dependant variable: vaccinated (with any influenza vaccine) in 2008/09 and abandoned vaccination in 2010/11 (n=49)(2)			
	n	Adjusted OR	95 % CI	p value	n	Adjusted OR	95% CI	p value
<b>Sex</b>								
Male	488	0.98	0.65–1.48	0.923	552	1.10	0.61–1.98	0.757
Female	562	Reference			470	Reference		
<b>Age group in 2008/09</b>					<b>Age group in 2010/11</b>			
Under 15 years	279	Reference			250	Reference		
15–24 years	124	10.75	3.03–38.18	<0.0001	141	10.65	1.95–58.18	0.006
25–34 years	141	6.65	1.67–26.60	0.007	125	23.70	3.58–157.16	0.001
35–44 years	175	4.80	1.23–18.68	0.024	169	8.31	1.19–57.92	0.033
45–54 years	166	10.58	2.91–38.53	<0.0001	171	10.83	1.65–71.31	0.013
55–64 years	165	23.15	6.39–83.85	<0.0001	166	18.35	2.88–116.97	0.002
<b>Educational level</b>								
Information not available	309	2.21	0.76–6.44	0.144	310	2.58	0.76–8.77	0.129
Primary education and lower	49	3.32	1.45–7.57	0.004	42	2.67	0.75–9.50	0.130
Secondary education	221	1.52	0.86–2.67	0.150	213	1.85	0.81–4.21	0.146
Upper secondary education	159	1.61	0.90–2.87	0.106	153	1.67	0.70–3.96	0.246
Higher education	312	Reference			304	Reference		0.386
<b>Monthly household income</b>								
Information not available	50	0.21	0.07–0.67	0.009	53	0.50	0.10–2.50	0.395
Under EUR 1,500	140	0.30	0.14–0.68	0.004	134	0.66	0.21–2.06	0.470
EUR 1,500–3,000	385	0.40	0.22–0.73	0.003	379	0.63	0.25–1.58	0.325
EUR 3,000–4,500	318	0.54	0.31–0.96	0.037	303	0.91	0.38–2.21	0.838
EUR 4,500 and higher	157	Reference			153	Reference		0.756
<b>Total of the sample</b>	<b>1,050</b>				<b>1,022</b>			

CI: confidence interval; OR: odds ratio.

the French population, as these factors have been documented to discourage vaccination behaviours [6–8,21]. This led not only to a low pandemic IVC in 2009/10 but also to subjects not renewing their vaccination behaviours in 2010/11. Especially concerning is this shift in vaccination behaviour among the age group 55 to 64 years, who will soon belong to the target group of people aged 65 years and over.

These results attest to a specific impact of the pandemic on target groups (Tables 2 and 3). In CoPanFlu data, target groups more frequently adopted both seasonal [22] and pandemic [23,24] vaccines during the pandemic than people with no risk factor ( $p<0.0001$ ). Target groups were in fact more likely to get both vaccinations than those with no risk factor, but subjects aged 65 years and over almost never relied only on the pandemic vaccine. Since past vaccination behaviours are known to influence later vaccination behaviours

[1,6,18,24], and people aged 65 years and over demonstrated high and superior IVCs across time [17], they seemed to have continued their usual seasonal vaccination practices, and adopting the additional protection from the pandemic vaccine. On the other hand, individuals younger than 65 years were more likely to use only the pandemic vaccine and had had a lower adherence to seasonal vaccination before the pandemic than other risk groups.

In the CoPanFlu cohort, the 2009 influenza pandemic did not alter post-pandemic vaccination behaviours among target groups as found in another French study conducted in 2010/11 [17]. In fact, individuals with risk factors constitute priority target groups for influenza immunisation programmes in France as in most industrialised countries [25,26] because they benefit most from the protection of the influenza vaccine [27], which would encourage them not to discontinue their



vaccination behaviours. It is however, of public health concern that the vaccination coverage in those target groups is still insufficient, below the 75% recommended by the World Health Organization [28], as has already been highlighted in several studies before the pandemic [15,16,25].

### Limitations and potential biases

In the CoPanFlu cohort, vaccination behaviours were stable before the 2009 pandemic (Tables 2 and 3), similar to other French studies [15,29]. IVCs among people over 65 years were comparable to other data [29,30], yet slightly lower than in the general population compared with previously published (though cross-sectional) results [31]. Prepandemic IVCs among individuals under 65 years with a risk condition were significantly lower (i.e. ranging from 34% to 38.3%) than those observed in other studies [29,30]. Moreover, the criteria for target groups used in this study were based on less restrictive clinical criteria (suffering or having suffered from a specific condition) those that of the French health insurance (i.e. based on enrolment in the long-term chronic disease programme for these specific diseases). Finally, the 2009/10 pandemic IVC in this cohort was higher than the 8% coverage observed in France [2,3], although in line with the IVC estimate of 11.1% from another French study on IVC during the pandemic [24].

We initially used participants' age at the inclusion as a default and stable variable in the results. When comparing behaviours between two seasons, we considered age at the later season to test for a behavioural change among subjects younger than 65 years who could have entered the risk group of people aged over 65 of age. However, even if some IVCs and results of the paired tests differed, the differences observed over time remained insignificant.

The CoPanFlu France cohort was originally designed to assess the relative risk of infection by the influenza A(H1N1)pdm09 virus, not the uptake of influenza vaccination. As indicated in a methodological paper by Lapidus et al. in 2012 [13]: *We first intended to include 1000 households (about 2100 subjects) which would have permitted to detect covariates associated to a relative risk  $\geq 1.4$  with a 80% power and 5% significance, assuming a cumulative incidence of 10% and intra-household correlation of 0.3.* However, due to organisational and financial constraints, only 575 households (1,451 subjects) were eventually included in the cohort. Theoretically, the maximal margin of error with a 95% CI is  $\pm 2.6$  for a random sample of 1,451 individuals and  $\pm 2.2$  for a random sample of 2,000 individuals. Due to the sample size and the possible subsequent lack of statistical power, changes in vaccination behaviours may have been more substantial in some population groups.

### Conclusion

These data illustrate the power of prospective household study designs to investigate behavioural changes in a context of global health crises. Contrary to Guthmann and colleagues [17], our study attests to a more lasting impact of the pandemic over the following two seasons, ultimately causing a decrease in IVC (with the possible exception of certain target groups at risk for complications). Secondly, it highlighted that people with no risk factors, and among them, young adults aged 24 to 34 years and people aged 45 to 64 years, were more affected by this trend. Although these groups could have been targeted by the pandemic vaccination campaign, this may also be influenced by the fact that influenza vaccination is not generally free of charge for these non-risk groups. Further studies should assess if this decreasing post-pandemic IVC trend is a temporary side-effect of the pandemic season or an indicator of a longer-lasting disaffection with the seasonal influenza vaccine or with vaccination in general, especially among at-risk populations. To do so, determinants of vaccination behaviours and motivations to get or not to get vaccinated should be more closely monitored.

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### Conflict of interest

None declared.

### Authors' contributions

Caille-Brillet Anne-Laure, Raude Jocelyn, Setbon Michel designed the purpose of this article and all authors contributed to the analysis and the interpretation of the data.

Caille-Brillet Anne-Laure and Lapidus Nathanaël conducted all statistical analyses.

All authors participated in the drafting and revision of this manuscript and gave their final approval of this version.

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